**NSF CREST MECIS – Fall 2023 Webinar Series – 11/17/2023**

**Presentation 1: Dr. Vagelis Papalexakis and Dr. Jia Chen, University of California-Riverside (UCR)**

**Title:** CARL-G: Clustering-Accelerated Representation Learning on Graphs

**Abstract:**

Self-supervised learning on graphs has made large strides in achieving great performance in various downstream tasks. However, many state-of-the-art methods suffer from a number of impediments, which prevent them from realizing their full potential. For instance, contrastive methods typically require negative sampling, which is often computationally costly. While non-contrastive methods avoid this expensive step, most existing methods either rely on overly complex architectures or dataset-specific augmentations. In this work, we ask: Can we borrow from classical unsupervised machine learning literature in order to overcome those obstacles? Guided by our key insight that the goal of distance-based clustering closely resembles that of contrastive learning: both attempt to pull representations of similar items together and dissimilar items apart. As a result, we propose CARL-G - a novel clustering-based framework for graph representation learning that uses a loss inspired by Cluster Validation Indices (CVIs), i.e., internal measures of cluster quality (no ground truth required). CARL-G is adaptable to different clustering methods and CVIs, and we show that with the right choice of clustering method and CVI, CARL-G outperforms node classification baselines on 4/5 datasets with up to a 79x training speedup compared to the best-performing baseline. CARL-G also performs at par or better than baselines in node clustering and similarity search tasks, training up to 1,500x faster than the best-performing baseline. Finally, we also provide theoretical foundations for the use of CVI-inspired losses in graph representation learning.

**Presentation 2: Dr. Bo Zou, University of Illinois – Chicago (UIC)**

**Title:** Planning Two-Echelon eVTOL-Based Package Delivery: Exploratory Modeling and Application to the Chicago Metropolitan Region

**Abstract:**

Advanced Air Mobility (AAM) holds great promise in revolutionizing human mobility, yet the predominant focus has been on its application in passenger transportation. In this research, we delve into the integration of electric vertical takeoff and landing aircraft (eVTOL), the most prominent air vehicle in the AAM landscape, into the domain of package delivery within metropolitan regions. The envisioned eVTOL-based delivery system is comprised in two legs. The first leg involves eVTOLs transporting packages from fulfillment centers to designated vertiports, where the packages are then handed over to ground vehicles for the final leg of the delivery to customers. We conduct a thorough analysis of the implications and distinctions between using gasoline and electric vans in this context. To facilitate the assessment, we have developed a comprehensive mixed-integer linear programming model. This model concurrently addresses the determination of optimal vertiport locations, the allocation of delivery zones to vertiports, the dispatching of eVTOL flights from a fulfillment center to vertiports, and the efficient routing of local ground vehicles. Our model is applied to a real-world scenario, specifically the northern suburbs of the Chicago metropolitan region, offering valuable insights into the potential of the eVTOL-based system to enhance cost efficiency and reduce the energy and climate impact of package delivery. The findings from this research serve as essential input for the development of freight-oriented eVTOL technology and business cases, inform investment decisions, and guide policy-making processes related to the establishment and operation of vertiport infrastructure for eVTOL-based package delivery.

**Presentation 3: Oscar De Leon, Master’s Student, University of Texas Rio Grande Valley (UTRGV)**

**Title:** Human-Centric Smart Cities: A Digital Twin-Oriented Design of Interactive Autonomous Vehicle

**Abstract:**

Autonomous vehicle (AV) technology is introduced as a solution to improve transportation safety by eliminating traffic accidents caused by human error as the main cause of 90% of accidents. One key feature of AVs is sensing and perceiving its surrounding environment through processing observations collected from the environment. This is essential for an AV to make an informed decision and safely navigate through the environment. To improve AV perception, this study presents an image semantic segmentation algorithm developed in the area of computer vision. The U-Net-based algorithm is trained and validated using a synthetically generated dataset in a simulation environment, namely, CAR Learning to Act (CARLA). The results indicate an improved accuracy of up to 98% compared to the existing methods. The performance of the proposed model is furthermore analyzed using various evaluation metrics.

**Presentation 4: Rodrigo Gonzalez, Master’s Student, University of Texas Rio Grande Valley (UTRGV)**

**Title:** Personalized Driving Using Inverse Reinforcement Learning

**Abstract:**

This research introduces an autonomous driving controller designed to replicate individual driving behaviors based on a provided demonstration. The controller employs Inverse Reinforcement Learning (IRL) to formulate the reward function associated with the provided demonstration. IRL is implemented through a dual-feedback loop system. The inner loop utilizes Q-learning, a model-free reinforcement learning technique, to optimize the Hamilton-Jacobi-Bellman (HJB) equation and derive an appropriate control solution. The outer loop leverages this derived control solution to generate parameters for the reward function, which are subsequently integrated into the HJB equation. The most optimal control policy is deduced from the final reward function obtained through IRL. To facilitate the recording of expert demonstrations and the evaluation of the final control policy, the Carla autonomous driving simulator is utilized.